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ABSTRACT

This address presents the results of a nationwide survey of science educators throughout Australia, including teachers, curriculum workers, and teacher educators. These educators were asked to comment on three categories related to science education: (1) past trends, (2) aims, and (3) future trends. Results of the past trends questions indicate a shift of emphasis from recall of factual knowledge to a recognition that subject matter may be a vehicle for achieving broader objectives involving understandings, attitudes, and skills. Also, a greater understanding and use of objectives in the development of curricula, teaching sequences, and resources is suggested. Other trends include increased professionalism, movement away from centrally determined curricula and movement towards integrated science curricula. Significant aims identified in the survey include skill development, attitude development, and scientific literacy. Future trends emphasize optimism about the future, a more humanistic approach, and an increased role of values in the curriculum. The author presents the results and leaves the choice for the future to the educators. (MA)

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SCIENCE CURRICULA IN AUSTRALIA - A NATIONAL VIEW

The Theme Address to Conasta XXVI - The Annual Conference of the Australian Science Teachers Association, Sydney

9th May 1977

by

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SCIENCE CURRICULA IN AUSTRALIA - A NATIONAL VIEW[1]

by Rex Meyer[2]

It is indeed an honour and a privilege to have been invited to give the theme address for Conasta XXVI; a conference which comes at a time of great activity and rethinking about science teaching in Australia - yet another turning point in the history of science education in this country. We can either move towards a largely impotent curriculum catering only for the needs of a special few, or to one of meaning and power and value for all pupils and for society. Which way shall we go?

Has There Been Significant Change in the Past?

Forgive me if I start to review the basic issues with some personal reminiscences. It is just twenty-five years since I established my first professional link with science teaching in schools - as a young university lecturer appointed as assistant examiner in Biology and Zoology for the NSW Leaving Certificate Examinations of 1952. A twenty-five year period, incidentally, that corresponds almost exactly to the present age of Conasta. Links with science teaching through examining, syllabus committees, in-service programs and the development of materials have continued unbroken from 1952 until now. This year (1977) sees the end of most of those commitments as I move into more general areas of education and so this conference and this opportunity to speak to science teachers is, for me, especially nostalgic.

In that period of twenty-five years I have been associated with and have observed many changes. There has been a great ebb and flow. Syllabuses and committees have come and gone; textbooks - some good, some fair and some bad - have been written and have vanished from the scene; multi-media packages and glossy national curricula have been in and out of print; there have been changing fashions in curriculum - some excellent and others just plain crazy; different

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(1) The "theme" address to Conasta XXVI, the Annual Conference of the Australian Science Teachers Association, Sydney, 9th May 1977

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views about aims and objectives have been in and out of favour and styles of testing and examining have shifted to and fro.

Some changes have been minor others major; some continuous and some not; and some have been negative, others positive, according, of course, to one's particular point of view. Can we total up all this change and say in general terms "that is where we have been" and "this is where we are now"? I suspect we can, at least to some extent, and I illustrate from questions from public examinations in Biology for the final school year in N.S.W.

In the first place consider the situation twenty-five years ago. Here are two typical questions from the Leaving Certificate Biology paper of 1952; my year of initiation as a science examiner (figure 1).

5. "Write an account of the way in which the frog, crayfish and *Amoeba* obtain food".

9. "Write an account of the life history of the moss and show how it differs from that of the fern".

Figure 1.

1952. Two Questions from the N.S.W. Leaving Certificate Examination in Biology. Courtesy: N.S.W. Board of Secondary School Studies

Now to move forward to the present day: The following items from a recent examination in Biology (figure 2).

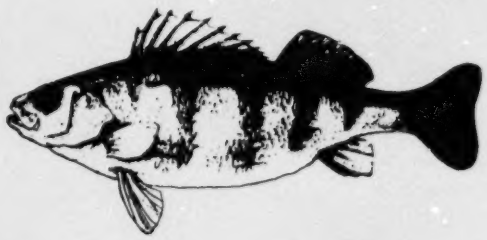
54. It has been stated that:

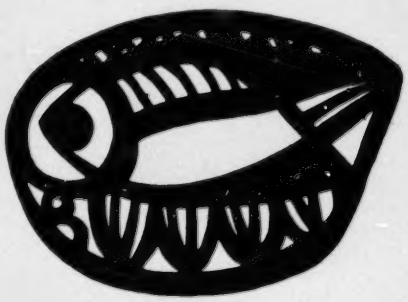
> "In school biology, discussion of human nutrition, biological warfare, agricultural chemicals and pesticides, and population growth is more crucial than the anatomy of an earthworm or the structure of a cell."
>
> *Professor L. C. Birch,*
> *Sydney Morning Herald, 13th July,* 1972.

Do you agree with this proposition? Select *one* of the topics referred to and justify your answer.

55. Betty and Jim are two university students. Betty is taking a course in biological science and Jim is studying fine art (painting and drawing). During their courses both Betty and Jim were required to observe a fish and prepare a drawing based on their observations. The same species of fish was used by each.

Study the following drawings. The top drawing was by Betty in biology and the bottom one by Jim in fine art.





(a) Discuss in what ways the drawings are similar and in what ways they are different.

and

(b) Speculate on some of the more general points of similarity and difference between science and fine art.

Figure 2.

1973. Two Questions from the N.S.W. Higher School Certificate Examination in Science (6 Period Trial Biology).
Courtesy : N.S.W. Board of Senior School Studies

Can we detect trends? What do the 1952 questions seem to have been testing? What do the more recent questions seem to test? What do the 1952 questions suggest about the teaching of biology twenty-five years ago? What do the more recent questions suggest about biology teaching today? To what extent can we generalize to other disciplines? Are these items indicators of fundamental or superficial change? What factors might have influenced the change? Is the direction of change appropriate or inappropriate? Will the direction and rate of change continue, stabilize of regress?

To help answer questions such as these I called on the opinions of colleagues. Letters were sent to 65 science educators throughout Australia, including teachers, curriculum workers and teacher educators. Three categories of problems were posed. For each category some educators were asked to comment for Australia as a whole, while others commented only on the situation in their own state or territory. The three categories were as follows:-

1) Past Trends: Opinions about the three most significant trends in school science since 1967. (Note the reduction from the twenty-five years of the earlier examples to a more realistic ten year period).

2) Aims: Opinions about the three most significant aims of teaching science, separately stated for each of primary school, the junior years of secondary school and the senior years of secondary school.

3) Future Trends: Predictions (not statements of hopes or desires) of the three most significant changes likely to occur in school science over the next twenty years.

Why only three answers in each category? Simply to force those responding to get priorities clear and to so identify only the most significant issues. Forty representative replies were received (see table 1) and the results are shown in tables 2 to 5.

Table 1. Numbers of Science Educators Giving Opinions on Past Trends, Desirable Aims and Future Developments in Science Education in Australia *

All Science Educators in the Survey		Science Educators replying on behalf of Australia as a whole		Total from Each State or the Territories
National, State or Territorial Region	No.	Origin by State or Territories	No.	
Australia as a whole	11			
New South Wales	12	New South Wales	2	14
Queensland	2	Queensland	0	2
South Australia	2	South Australia	2	4
Tasmania	1	Tasmania	0	1
Victoria	4	Victoria	5	9
Western Australia	5	Western Australia	0	5
Territories	3	Territories	2	5
Total	40		11	40

* Eleven science educators responded on behalf of Australia as a whole; the remainder on behalf of their States or Territories

Three aspects of the results in tables 2 to 4 require some interpretation.

Firstly, points made by those responding on behalf of Australia as a whole are shown as originating in all states and the two territories. Secondly, decisions about similarities between ideas; amalgamation of similar statements and the splitting and redistribution of parts of compound statements, had to be made, and these decisions were partly subjective. Thirdly, while each educator was asked for three comments on each aspect some gave more than three and some gave less, but all answers were included in the data. These aspects explain why the numbers of statements in each problem area do not add to 120 (i.e. 40 x 3).

Incidentally, it is of interest to note some correspondence between the findings of this present survey and the trends and objectives identified by Gregor Ramsay in his report for ACER of 1972 (1) and by Professor Kwong Lee Dow in his book (1971) Teaching Science in Australian Schools (2).

Referring once again to the examination items illustrated in Figures 1 and 2 comparisons are invited between trends they represent and trends revealed by the survey as shown in table 2.

Table 2. The Most Significant Trends in Science Education in Australia from 1967 to 1977 as Assessed by Forty Science Educators. (Representative of all States and two Territories).

Past Trend	Frequency of Mention	States and Territories
I. Curriculum		
1.1 Reduction in role of state-wide syllabuses as decisions about curriculum return to individual teachers.	28	All
1.2 Broadening of aims to include understandings attitudes and skills with less emphasis on memory work	15	All
1.3 Greater understanding and use of objectives in the development of curricula, teaching sequences and resources.	10	Almost all but especially NSW, SA, and Vic.
1.4 Reduction in proportion of the total curriculum devoted to science, especially in the lower secondary school.	8	All except Tas. and WA.
1.5 Move towards an interdisciplinary approach and a fusion with non-science elements such as social and environmental science (especially in junior secondary school). Science seen more as part of a total curriculum.	8	All
1.6 Greater diversification of types of science courses catering for different needs and interests (e.g. academic versus general needs in Forms XI and XII).	7	All but especially SA, Vic., WA and ACT.
1.7 Reduction in academic rigour, sequential structure and quantitative aspects and greater emphasis on application to life and social relevance.	6	All
1.8 A swing from physical science (especially physics) towards biology and human biology.	5	Most
1.9 Change to a more humanistic approach stressing development, understanding and appreciation of values.	3	Especially NSW
1.10 Increased emphasis on science rather than nature study in the primary school	3	All
1.11 Some scepticism (in society at large) about the role of federal curriculum projects of the past (e.g. ASEP). No longer an automatic view of the intrinsic value of science that must pay dividends in the future.	1	All

Table 2. (Cont/d.)

Past Trend	Frequency of Mention	States and Territories
II. Learning Resources		
2.1 Decline in use of the omnibus textbook and introduction of flexible units in form of modules or minicourses.	30	All
2.2 Increased emphasis on selection from a range of alternative materials.	6	All
2.3 Greater use of media and educational technology.	3	Mainly NSW, Tas. and Vic.
2.4 Greater co-operation between teachers and non-teachers such as psychologists, editors and scientists in the production of learning resources.	2	All
2.5 Increased awareness of the problem of readability in printed materials.	1	SA only
III. Strategies and Methods		
3.1 Greater emphasis on self-paced learning and on matching strategies and methods with the needs of individuals.	30	All
3.2 Increased emphasis on practical work and active participation.	14	All
3.3 Greater emphasis on learning rather than teaching - a more child-centred approach.	12	Almost All
3.4 Greater use of community resources, involvement of community groups and visits away from the school.	3	Mainly NSW, and Q'land
3.5 Greater emphasis on team teaching and open plan methods.	2	ACT only
IV. Facilities		
4.1 Improved facilities in laboratories, equipment and library resources (especially in Forms 7 to 10)	9	Almost all
4.2 Greater availability of laboratory assistants and other aides.	6	Especially NSW, Q'land and WA.
4.3 Reduction in the size of classes	2	Especially Vic.
V. Assessment		
5.1 Decline in status and influence of public examinations.	25	All
5.2 Increased innovation in assessment by individual teachers and by state systems.	22	All

Table 2. (Cont/d.)

	Past Trend	Frequency of Mention	States and Territories
VI.	Teachers		
6.1	Increase in general professionalism	4	Especially NSW and NT
6.2	Greater emphasis on inservice education and diversification in pre-service training.	4	Especially NSW, Q'land and WA
6.3	Appointment of curriculum advisers and consultants.	2	All, but especially NSW and SA
6.4	Greater emphasis on development of management skills.	1	NSW only

In the first place the examination questions reflect a trend, identified in the survey (Table 2, item 1.2), from an emphasis on recall of factual knowledge towards a recognition that subject matter may be a vehicle for achieving broader objectives involving understandings, attitudes and skills. Note, however, that the more recent examination items also demand knowledge, in fact quite a lot of knowledge, but this is not required for its own sake, but as part of a process of interpretation and valueing.

Secondly, both the examination questions and the results in Table 2 suggest that there has been a change from straight memory work towards knowledge and appreciation of the processes of science and of resolving problems involving value judgements. Notice particularly, however, that those responding to the survey avoided catch-phrases such as "discovery learning" and stressed instead phrases such as "child centred"; "active participation", "greater emphasis on learning rather than teaching" and "matching strategies to the needs of individuals". This rejection of doctrinaire approaches and fashions such as "discovery learning" is commendable. The problem with such "blanket" approaches to curriculum is that some teachers accept them as dogma and proceed stubbornly to apply methods which are not universally appropriate. There is now overwhelming evidence to show that discovery learning, for example, can be (and I quote from a recent report by NFER) "a tool of great power and effectiveness in the

hands of teachers in the right situations, but when used indiscriminately it can do as much harm as good".(3)

Thirdly, those in the survey made an important point about the greater understanding and use of objectives in the development of curricula, teaching sequences and resources. This trend is also reflected in the shift from the content approach of 1952 to testing achievement of complex objectives such as those reflected in the question about the fish, set in 1973. Test items such as the fish example, imply that a definite range of objectives should have been made clear to both teachers and learners at the outset of the course or unit of work. These objectives, in the case of the example, should have included something about an understanding and valueing of of relationships between fine art and science; about understanding the limitations of science and of processes such as observation, recording of data, subjectivity in interpretation, accuracy, and the role of explanatory models in describing phenomena. The spelling out of clear achievable objectives or outcomes, expressed in terms of minimal changes in behaviour, for whole courses, units of work and for specific lessons, has been a major factor in tightening the efficiency and effectiveness of learning and has provided a powerful cutting tool for selecting appropriate content and method. Tests and examinations have become more valid because the same objectives have become clear to both the tester and to the candidate. There are, of course, the critics of the "objectives approach". There have been charges of "behaviourist control" "regimentation" and "indoctrination". And, in view of earlier comments about doctrinaire attitudes, this would be fair comment if the "objectives approach" were to be used indiscriminately whether appropriate or not. It has, however, provided a valuable addition to the repertoire of the discriminating teacher. As Robert Mager says "if you are not sure where you're going, you're liable to end up somewhere else - and not even know it." (4)

What else about the test items? Clearly the recent examination questions reflect a move towards greater social relevance, and towards understanding the individual learner and his needs - that is towards a more humanistic approach. These trends were also identified in the survey (Table 2). But these changes in turn, imply that considerable changes must have occurred in the skills and competencies of the teaching staff. Science teachers have become more

professionally oriented, more child-centred in outlook and more skilful in helping students achieve the sophisticated goals of the newer curricula.

This increased professionalism has been influenced by a number of factors. The availability of flexible modular resources, involving activity and the use of varied media has been especially significant. Materials produced by ASEP and the partially completed NSCM projects are exemplars of this (5). Another factor has been the massive expansion of in-service education with its emphasis on professionalism and teaching skill rather than on the content of a particular program. Further factors have been the development of better facilities for practical work and the emergence of more enlightened curricula. These trends, incidentally, were all identified by those responding to the survey.

Two especially significant trends emerged from the survey, however, that could not, by their nature, be detected from the evidence of examination items.

The first of these is the strong move away from centrally determined curricula and examinations towards returning responsibility for curriculum and assessment to the teachers. In some states this has been achieved by moderation of centrally determined courses and examinations and in others by their total abolition. This is a vital and essential move but one fraught with grave dangers and risks unless appropriate steps are taken to avoid them. I will say more on this later when we look to the future.

The second of these trends has been the move towards programs of integrated science and fusion with non-science elements of the curriculum. Integrated programs are widely taught at primary and junior secondary levels in most states and they are emerging, too, in senior grades. This trend would have proceeded more rapidly at senior level, if it were not for the vested interests or misguided philanthropy of those whom I tend to call the FRS group - FRS, by the way, standing for "Foolish Research-oriented Scientist". N.S.W., for example, muffed its opportunity to convert its unsatisfactory "Wyndham" program of correlated science into a fully integrated course, and it recently returned, tail between the legs, to the comfort and security of separate sciences based on already

outmoded "package deals". It seems, though, that even in N.S.W. the FRS influence is diminishing and there is a quiet move towards more flexible approaches based on the idea of a core and electives. This is consistent with trends in other states towards greater flexibility through the use of elective units, modules and mini-courses - a trend strongly influenced by ASEP materials.

Past Trends in the United States of America

One final point about past trends. It is of interest to note areas of agreement and of difference between Australia and the United States. In an address to Conasta in May 1973, Dr.Marjorie Gardner of the University of Maryland, identified eleven recent trends in science education in America (6). Of these, seven were also identified in the present survey in Australia - these are listed in Table 2, items 1.1, 1.5, 1.9, 2.1, 3.1, 3.5 and 5.2. Four trends, important in the United States in 1973, did not appear to be significant in Australia in 1977, but some may now just be starting to make an impact here.

The four trends significant only in the United States were as follows;-

1. Greater use of S.I. units and standard nomenclature
2. Recognition that the staff of teacher training institutions require specialized training
3. A movement away from expensive "hardware courses" (the "kit" approach) to a philosophy of "make-do-with-what-we-have".
4. Restricted budgets leading to "educational belt tightening" and to attempts to achieve objectives more efficiently

So much then for past trends. Quite a change over the ten years and an even more dramatic change for older hands such as myself.

The Most Significant Aims of Science Teaching

With regard to results of the survey on aims I do not propose to make detailed comment because the views of the criterion group are largely self evident (Table 3). But there are some surprises and I will draw attention to these.

Table 3: The Most Significant Aims of Science Teaching in School as Assessed by Forty Science Educators. (Representative of all States and Two Territories).

(Arranged in Order of Frequency of Mention for each Level of the School System)

I. Primary School

	Aim	Frequency of Mention	States and Territories
1.1	To develop willingness to investigate natural and man-made phenomena at the level of concrete operations.	30	All
1.2	To develop interest, curiosity and wonder about natural and man-made phenomena.	18	All
1.3	To expose pupils to a wide range of phenomena and to develop their general knowledge of science.	17	All
1.4	To develop skill in the very basic scientific processes for describing the world (e.g. measuring, weighing, classifying).	13	All
1.5	To develop skill in the interpretation of biological, physical and social aspects of the environment of pupils.	6	All
1.6	To develop the skills and insights necessary to satisfy intellectual curiosity.	5	All
1.7	To develop skills in communication.	4	NSW, WA and ACT only
1.8	To cater for pupils' interests and potential interests in their environment.	3	Tas., Vic. and ACT only
1.9	To understand the world and how to survive in it.	2	NSW and WA only
1.10	To develop confidence in pupils that their observations and opinions are worthy of respect.	1	Vic. only
1.11	To develop understanding of the role and limitations of technology in society.	1	WA only

Table 3. (Cont/d.)

II. Junior Secondary School

	Aim	Frequency of Mention	States and Territories
2.1	To develop the skills of problem solving and enquiry.	28	All
2.2	To develop understandings and skills necessary for explaining everyday phenomena.	27	All
2.3	To develop an intellectual curiosity about and interest in natural phenomena.	13	All
2.4	To help pupils understand themselves as functioning human being within the total environment.	9	All
2.5	To develop awareness and appreciation of the social implications of phenomena.	9	All
2.6	To develop an understanding of the processes of science - observation, classification, model building, etc.	8	All
2.7	To develop an understanding of the impact of science on the human and physical environment.	7	All
2.8	To cultivate an attitude of respect for scientific methods of gaining evidence and of testing the adequacy of ideas.	7	All
2.9	To develop an understanding of the limitations of science.	6	All
2.10	To develop a concern for the impact of science and technology on society and on social values.	5	All
2.11	To assist students in their development of learning skills.	4	All
2.12	To develop an understanding of the world and how to survive in it.	4	NSW, Vic.and WA only
2.13	To develop communication skills.	3	NSW and WA only
2.14	To build a good foundation for further studies in science.	3	SA, WA and NT only
2.15	To develop sensitivity to and understanding of values and moral issues in the society.	2	All
2.16	To develop awareness of the interconnectedness of phenomena.	2	All
2.17	To develop the basic manipulative skills necessary for scientific experimentation.	1	ACT only
2.18	To develop the concept of a scientific discipline.	1	NSW only

Table 3. (Cont/d.)

III. Senior Secondary School

	Aim	Frequency of Mention	States and Territories
3.1	To develop an understanding of the nature of science including its processes and limitations.	22	All
3.2	To develop knowledge and understanding of the key ideas of one or more of the scientific disciplines.	20	All
3.3	To develop some insight into social, political and economic aspects of science.	18	All
3.4	To help students prepare for tertiary level studies in science.	11	All
3.5	To develop skills of problem solving and of critical thought.	9	All
3.6	To sustain enthusiasm, curiosity and wonder about the natural world.	8	All
3.7	To develop manipulative skills.	7	All
3.8	To increase understanding of the physical and biological environment of man.	6	All
3.9	To develop academic self discipline and a desire for further education.	4	NSW, Vic. and WA only
3.10	To develop a sense of intellectual rigour from the study of scientific disciplines.	4	All
3.11	To develop a willingness to pursue science as a liberal study in its own right as part of general education.	3	All
3.12	To help students learn to value the world and its natural resources.	3	NSW and Vic. only
3.13	To develop willingness and ability to persevere with a task.	3	NSW only
3.14	To develop an understanding of man and of his interpersonal relationships.	1	All
3.15	To foster individual development in special areas of interest and aptitude.	1	WA only
3.16	To inform students of opportunities for science based careers.	1	Vic. only

Notice, for example, a quantitative trend from level to level. For the primary school there were 100 statements, 110 for the junior secondary school and 121 for the senior secondary school. This suggests an increasing divergence of opinion from junior to senior levels. Perhaps not really all that surprising, but it counters the idea that academic pressures of the senior years would tend to force convergence rather than a divergence of opinion.

A more significant pattern, however, is the change in emphasis from level to level. For primary school about 44% of the objectives involved cognition, 52% the affective area and 17% manipulative skills. (Incidentally, percentages do not add to 100 because some statements could be classified in more than one group and others could not be categorised at all). In the junior years of secondary school the cognitive area was dominant (79%), the affective about 26% and the skills area only 3%. A dramatic shift in favour of knowledge and understanding at the expense of other objectives. In the senior school the situation was 82% for cognition; only 4% for the affective area and 6% for skills. A startling decline in emphasis on attitudes. This result has implications for the future and this will be considered further in the section reviewing data on future trends.

Another somewhat unexpected aspect was the rather conservative approach of some in the survey - admittedly a minority, but a minority of what may be considered a criterion group. For example, at the junior secondary level, of the 110 statements made at least 30% could be regarded as heavily subject-oriented. At the senior secondary level this figure rose to 40%.

But, at least from my personal point of view, the most encouraging aspect of these results was the dramatic change they represent from the situation of about 25 years ago! In 1955 a modest survey was undertaken of the views of science teachers in N.S.W. on desirable aims of biology teaching (Meyer) (7). Very few statements emerged other than the following -

(1) to ensure a pass in the public examination
(2) to develop an appreciation of living things
and(3) to understand the "scientific method" - defined very formally

No doubt 1977 shows an advance on the narrow views of 1955 - another indicator of the increased professionalism of science teachers in Australia. Nevertheless the conflicts between the needs of the learner and the needs of a discipline are by no means resolved even now - especially in senior years. Are students to serve science? Or is science to serve the students?

So we enter the next decades with some unresolved problems and with many questions.

Predictions About the Future

In considering the results of the survey with regard to the future it is important to keep in mind that those who responded were not asked about what they would like to happen but for predictions of what would happen. Also, as they were each limited to only three predictions, the list represents views about only the most significant trends. The results of this aspect of the survey are shown in Table 4.

Table 4. The Most Significant Trends Predicted for Science Education in Australia for the Next Twenty Years Based on the Opinions of forty Science Educators. (Representative of all States and two Territories).

	Future Trend	Frequency of Mention	States and Territories
I.	Curriculum		
1.1	Greater diversity and flexibility giving wider options for both academically and less academically minded students.	20	All
1.2	Greater integration of science with other single elements of the curriculum such as social and environmental science.	18	All
1.3	Continued reduction in the status of subject matter *per se* and a greater emphasis on the development of generalised attitudes, skills and values.	8	All
1.4	Greater recognition that most students at school are non-science orientated and the the development of integrated general programs for these students.	7	All
1.5	Greater community involvement in all aspects of educational planning, but especially in curriculum.	6	All

Table 4. (cont'd.)

	Future Trend	Frequency of Mention	States and Territories
1.6	Continued reduction (at least initially) in numbers taking physical science and increase in the popularity of biology and human biology, especially in Forms XI and XII.	6	All
1.7	The merging of science into a totally fused school curriculum preparing students for life.	5	All but especially NSW and WA
1.8	A return to a more rigorous and systematic study of science for the academically minded student in all forms.	5	All but especially NSW, SA, Vic. and NT
1.9	Moves towards curriculum development tied closely to an articulated program for the pre-service and inservice education of teachers.	5	All but especially NSW and WA
1.10	A greater emphasis given to conservation education and the management of resources.	5	NSW, Q'land and WA
1.11	The 'coming of age' of primary science programs based on the process approach.	5	NSW, Vic. and WA
1.12	Greater emphasis on vocational guidance and job involvement.	5	NSW, Vic. and WA
1.13	A further reduction (at least initially) in the time given to science programs in general education to Form X.	4	All but especially NSW and NT
1.14	Selection of more recent content of greater relevance to everyday life.	4	NSW, SA and Vic.
1.15	Greater use of the experience and interests of students in curriculum planning.	3	All (especially) NSW and Vic.
1.16	Development of special courses in science for pre-vocational groups such as nurses.	2	WA only
1.17	Greater attention to be given to evaluation of curricula.	2	All
1.18	Rejection by more critically minded students of an education reduced to training for and induction into a pre-defined social and economic order.	2	All
1.19	Resolution of the residual conflict between the relative importance of factual detail and the big ideas of science.	2	All but especially NSW
1.20	A redevelopment of integrated science programs at all levels, especially for Forms XI and XII.	2	NSW and WA
1.21	A return to a greater emphasis on knowledge of scientific concepts in the junior secondary school.	1	NSW only

Table 4. (Cont'd.)

	Future Trend	Frequency of Mention	States and Territories
1.22	A greater emphasis on specification of minimal outcomes in terms of performance.	1	All
1.23	A return to centrally developed curricula and objectives.	1	SA only
1.24	Resolution of conflicts arising between school based curricula and central decision making.	1	WA only
1.25	A greater emphasis given to safety education in science.	1	SA only
1.26	An increased emphasis on language development.	1	Vic. only
1.27	Reintroduction of technology into the science curriculum.	1	Vic. only
1.28	A continued reduction in quantitative work at all levels.	1	Q'land only
1.29	Improvement in pre-school curricula as preparation for primary school science.	1	Q'land only
1.30	Possible continuation of a trend towards 'unreason' leading to the total abolition of science in the school.	1	Vic. only
II.	Learning Resources		
2.1	A greater diversification of learning resources.	2	All
III.	Strategies and Methods		
3.1	A greater stress on individualisation, especially on the matching of strategies and methods to individual styles of learning.	12	All
3.2	A greater use of computers in the development of simulations.	5	All but especially NSW
3.3	A considerable increase in the range of strategies available for teaching science.	5	All but especially SA and Tas.
3.4	Increased application of educational technology.	5	All but especially NSW
3.5	A continued increase in the use of laboratory facilities for the development of investigatory skills.	4	All but especially NSW and Q'land.
3.6	A further development of learning experiences away from the classroom.	4	All but especially Q'land and WA

Table 4. (Cont/d)

	Future Trend	Frequency of Mention	States and Territories
3.7	Continued development of team teaching and open plan methods.	3	All but especially WA and ACT
3.8	A swing away from 'package deals' to more traditional methods.	1	NSW only
IV.	Facilities		
4.1	Maintenance of adequate facilities for effective teaching.	1	All
4.2	Continued reduction in the size of classes.	1	WA only
4.3	Greater use of computers for organisational matters and records.	1	NSW only
4.4	Development of facilities away from the classroom e.g. outdoor biology laboratories in school grounds.	1	All
V.	Assessment		
5.1	A greater use of computers in diagnostic testing.	5	All but especially NSW
5.2	Modification or abandonment of the remaining external examinations.	3	All but especially NSW and Vic.
5.3	Continued innovation in assessment e.g. development of item banks; criterion reference testing and mastery learning.	1	Tas. only
VI.	Teachers		
6.1	Development through inservice education of increased skill in diversifying strategies and in matching them to the needs of individuals.	7	All but especially NSW and Q'land
6.2	Greater emphasis on training teachers in the skills of curriculum development.	6	All but especially Vic.
6.3	Continued expansion of inservice education and the further development of general professionalism.	5	All but especially NSW, Q'land and WA
6.4	Greater attention given to training science teachers in mathematics and in a broad range of science subjects.	1	All

	Future Trend	Frequency of Mention	States and Territories
6.5	Development of training programs for science teachers involving a balance between science and the humanities.	1	Vic. only
6.6	In primary schools, use of non-specialist advisers and science specialists to help the more generally trained primary teacher.	1	NSW only
6.7	A greater emphasis in training programs on the applications of educational technology.	1	NSW only

What can we make of these data?

In the first place there was a greater divergence of opinion about the future, than about the relative significance of past trends. Results in Table 5 show that the forty educators between them, mentioned 30 past trends, but made 53 predictions about the future. In the case of the past, 12 out of 30 trends were mentioned by eight or more educators. With regard to the future only 4 of the 53 predictions were mentioned by eight or more educators. These four predictions were as follows:

- more diversity and flexibility in the curriculum (Table 4. item 1.1)
- greater integration of subject matter (Table 4. item 1.2)
- greater emphasis on general educational objectives (Table 4. item 1.3)
- greater stress on individual work and in matching strategies to particular styles of learning (Table 4. item 3.1)

Table 5. Comparisons Between the Numbers of Most Significant Past Trends and Future Predictions for School Science in Australia Made by Forty Science Educators.

Category	Number of Significant Trends 1967 to 1977	Number of Predictions 1977 to 1997
1. Curriculum	11	30
2. Learning Resources	5	1
3. Strategies and Methods	5	8
4. Facilities	3	4
5. Assessment	2	3
6. Teachers	4	7
Total	30	53

For the rest, not much in common, but some issues do emerge.

In the first place there was considerable emphasis on curriculum (see Table 5) - an area, obviously, of greatest future concern. There was little mention of resources and facilities. Only 5 out of 53 statements referred to resources and facilities and these were remarkably optimistic in view of present Federal economies. It seems that these areas remained uncertain because the curriculum was uncertain and the one clearly flows from the other.

It was interesting to note an over-all optimism about the future. Most of the forty educators saw continued expansion of school science; greater professional awareness of educational principles; and increased opportunities for teachers to develop status, role and expertize. Some, a small minority, were gloomy, one mentioning the possibility of the total abolition of school science in the face of superficiality and the "cult of unreason" and others seeing some decline in the status of science education. One or two saw an initial period of decline followed by a recovery towards the end of the century.

There was a clear split in opinion about the direction of future change. The majority predicted greater integration, more humanism, emphasis on broad general objectives and a greater attention to the needs of individuals, with continued innovation in strategies, resources and methods of assessment. A minority (less than 5%) predicted a return to the rigour of the disciplines; to centrally determined curricula and public examinations and to traditional methods of teaching.

One aspect of concern was a degree of consensus suggesting that attitudinal objectives would not necessarily emerge as paramount in the future. This aspect will be discussed later.

Many predictions about the future tied in with the analysis of the past and with views about aims. Two examples of such links touched on earlier were the problems of curriculum autonomy and the question of the place of attitudes and "values" in the science program. This paper concludes with some consideration of each of these issues and with the development of an over-all model linking the past, the present and the future.

The Problem of Curriculum Autonomy

School based curriculum development, with its flow on to locally devised resources, strategies and methods of assessment, has every educational argument in its favour. It meets local needs, caters better for individuals and capitalizes on local skills and resources. It has been suggested earlier, however, that this policy is also dangerous. The danger is twofold. In the first place, under present awards, teachers just do not have time for such things. Curriculum autonomy brings freedom and responsibility, but under present circumstances, it also makes intolerable demands. I become impatient with those industrial unions which always press for reduction in the size of classes. Who cares about class size? Except in special circumstances, that should be a matter for the appropriate teaching strategy. What is important, and about which we hear little, is reduction in contact hours. I believe, that if teachers are to respond professionally to the increasing demands of the future, they need at least "one hour off for every one hour on". The time "off" of course not for collapsing into a semi-comatose state in the staff room after three periods with 2Z, but for working on professional matters such as the development of courses, production of materials or for organizing assessment programs.

Curriculum autonomy not only implies the need for more time, but also for considerable expertize. I was therefore surprised and somewhat dismayed to note the scant attention paid by many in the survey to problems of the future education of the science teacher. Not only must inservice programs expand and diversify to meet new demands such as curriculum responsibility, they must also change direction to focus on the needs of individual teachers, on the needs of, say, all the staff of the science department, or, at times, on the needs of the whole staff of the school. I would hope to see "five year plans" of professional development - for individuals, groups within the school, and for the whole staff. In the latter case the emphasis would need to be on development and growth of the total school as a dynamic organization of interacting people. All this, of course, assumes that the previous condition holds - that there has been the reduction in contact hours necessary to accommodate this "school focused" inservice program.

Lots of money involved? A doubling of the number of teachers on the pay-roll? Yes, perhaps, but we are potentially, an affluent nation, underspending on education. I am confident that, the present economic recession over, this policy could prevail.

The Place of Values in the Science Program

Finally, and probably most important of all, there remains the question of "values" in science education. Some decline in emphasis, by those surveyed, on affective objectives from junior to senior levels has already been reported, as was some consensus suggesting that attitudinal aspects may not necessarily be major areas of future concern.

In fact, this whole area of attitudinal development leading in turn to the question of "values" in the curriculum, is, to me, the main issue - the turning point for progress or decline in the future. I see this moment in the history of science teaching in Australia, as a real crisis point - a crisis of and about values.

When pinned down, as academic educators often are, to answer the perennial question "What is the central aim of education?", I usually commit myself to the following answer. "It is surely," I say, "to develop those understandings, attitudes and skills that enable meaningful value judgements to be made throughout life." After all, isn't that what living is all about - making decisions? We weigh evidence and make a choice, and each decision is a choice between two or more systems of values. "Will we rent or buy?" "Will I marry John from next door or Bill, the lad I met at university?" "Which brand of toothpaste will I choose?" - major decisions; minor decisions; the trivia of the day - all involving valueing. Is valueing to be based on pure emotion, prejudice,rumour and vague impression or on understanding, appreciation and insight?

"Oh! I see now, we will be better off renting for a while, Tom was wrong in advising us to buy, and you know why that Estate Agent was pushing so hard! Look at this, Anne, the evidence is clear. I have all the statistics. No we can't buy the house we saw yesterday just because we both liked the view from the kitchen window!"

All about values - what they are like, where they come from and how they control our decisions.

Who better to contribute to this type of personal development - to the achievement of this aim of education - than the science teacher. The science teacher can offer process, the tools of problem solving, the objective analysis of attitudes and more than a fair share of relevant subject matter.

A Scenario Linking Past Present and Future

If you agree with my views about the central aim of education, then past present and future come together into a linear sequence and there is a clear blueprint for science teaching for many years ahead. If you reject these views, then you must find an alternative destiny.

My scenario for science teaching in Australia is as follows - (see Figure 3)

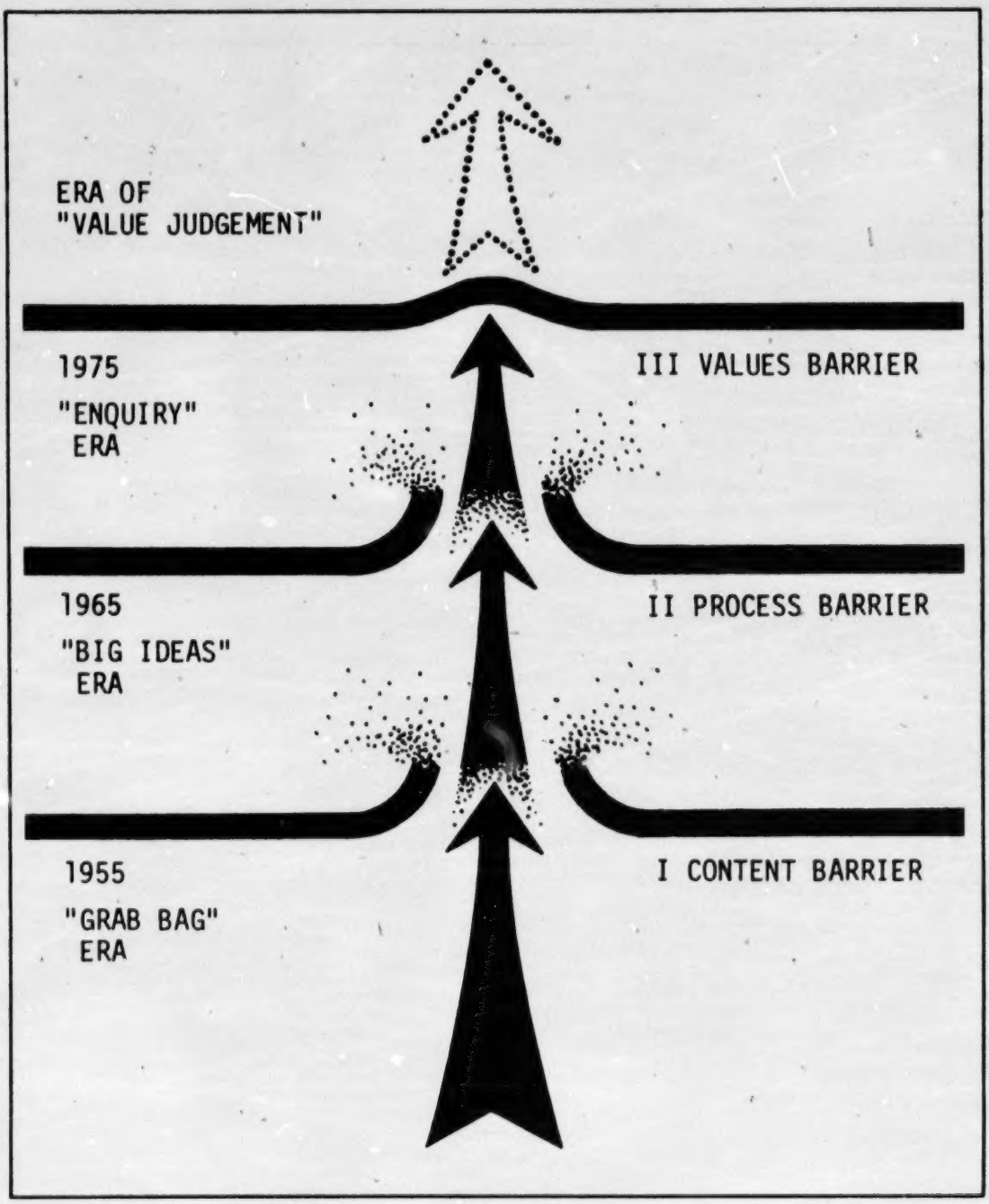


Figure 3.

A scenario for science teaching in Australia. Past Present and Future form a linear development. Key characteristics of each "era" are cumulative and significant barriers to progress are thrust aside as professional expertize grows and matures (see text for further discussion)

Just after World War II, science in schools was largely a loose collection of facts derived from a traditional area of knowledge - a 'discipline' or 'subject'. The information, frequently selected as an arbitrary whim, was often trivial and poorly linked together by any criteria, much less as learning hierarchies. This was the "Grab-Bag" Era. It was the hey-day of memory work, disciplined learning and the "recipe book" of science methods.

A break-through came in the mid-fifties with the realization that subject matter could be selected and arranged to enhance the learning of central concepts or "big ideas" of a particular discipline. We had broken through the "content barrier". From 1955 to 1965, therefore, science curricula tended to reject isolated fragments of information and stressed major ideas such as energy, photosynthesis or the principles of stratigraphy. "Lesser" concepts were selected and arranged so that they led cumulatively to an understanding of the "big" ideas.

By the mid sixties, however, we had begun to react to influences from overseas, especially to the work of psychologists such as Bloom and Bruner and to the world drift towards "discovery learning", "problem solving" and the "processes" of science. We broke through the "process barrier" to an era of "discovery-oriented" programs.

We started with a simplistic definition of "discovery" - we thought of it at first simply as an empirical process but we gradually moved towards "guided discovery". We enjoyed a decade of gradual reassessment and moderation of the role of discovery methods in teaching and learning. Certainly by 1975 many were having doubts about such doctrinaire methods and had begun to diversify strategies to match methods with individual styles of learning. We began, too, to see subject matter as a vehicle for attaining important educational goals and to reject content as an end in itself.

But we then found a new barrier ahead - the "values barrier". A few began asking the key questions - the only questions that matter. Discovery learning about what? Enquiry about what? Problem solving skills for what purpose? Some saw that there could be problem solving involving judgements about values. See, for example, the

emphasis given to attitudes in the aims of the new syllabuses for School Certificate Science in New South Wales (8). They began knocking on the "values barrier". It is bending a little, but we have not broken through yet.

What will it be like if we do break through? Will the teacher sit with students and just talk all day about values - a mutual exchange of prejudice and ignorance? No not at all. The interesting thing about the progression from era to era (Figure 3) is that it has left very little behind as it has moved forward - it is cumulative of the best features of the past. From the "Grab-Bag" Era we retain lower level facts, the skills of memory work and of self discipline in learning; from the era of "Big Ideas" we keep relevant major concepts and understand their derivations; from the era of enquiry we have learnt to individualize and to vary strategies so as to develop skills of problem solving in all learners; in the era of value judgements we bring all this together in a "confluence" of understandings, attitudes, skills and insights to resolve conflicts between values. We do this through science, not through prejudice, not through emotive ignorance and not by passive submission to indoctrination.

We can achieve these objectives in two ways. Firstly, as science concepts emerge, by whatever strategy, affective elements and associated values may be identified and analyzed. What was <u>really</u> the nature and origin of the prejudice against Darwin? Why did Darwin persist? What factors determined <u>his</u> values? Secondly, as incidents occur at school or in the local community, their value components can be revealed and analysed - incidents varying from the significant to the trivial. In the conflict, say, between sand-miners and conservationists, what is the <u>exact</u> position of each group? How do we know if our assessment is accurate? What are the origins of these values? How much of the conflict is due to prejudice, ignorance, vested interest, bias or unreasoning fear? Can the conflict be resolved? Surely, a major issue for the community at large. Minor crises at the school level, however, can be equally significant in terms of processes and procedure. Perhaps there may be a conflict between the proprietor of the school canteen and the staff of Home Economics about the quality and nutritional value of the food on sale. Is it to be whole-meal sandwiches, fruit and milk;or pies, sweets and soft drink? Isn't that essentially the same type of problem as the

sand mining issue, but on a smaller scale? In all such cases insight comes only after knowledge, understanding and skill and through the analysis of attitudes and values. No-one is suggesting that we stop teaching about facts - facts underpin all understanding, attitudes and values - but they are building blocks, not ends in themselves.

In the United States at present there is a strong beginning towards a "confluence" between affective and cognitive aspects of science in a valueing curriculum. The trend was given initial impetus by two important publications. The first was the NEA report Values and the Curriculum published in 1970 (9) and the second the booklet issued by NSTA in 1971 Behavioural Objectives in the Affective Domain (10). There is also the more general book published in 1972 by Simon, Howe and Kirschenbaum Values Clarification - a Handbook of Practical Strategies for Teachers and Students (11) - interesting as a somewhat extreme view but not particularly oriented towards science. More recently Bill Romey of ESCP fame has championed the "values approach" and his latest book (1976) Confluent Education in Science is a key reference (12).

The trend towards an emphasis on values is also more broadly international. Albert Baez, in his book published by UNESCO in 1976, Innovation in Science Education World Wide (13), comments -

> "I believe that the ultimate aim of science education ... should be the development of sensitive human beings, informed and competent in the subject matter and methods of science, and possessing a sense of social responsibility"

Conclusion

So the issue whether science stays on as a recognizably separate part of the curriculum or as a merger with other disciplines, or becomes part of a total curriculum for life, is really a secondary and relatively unimportant question. It is an issue of the past. The packaging doesn't matter, it is the value of the contents that counts. Mr. FRS can go paddle his own canoe! That is my value judgement. The science teacher can be concerned with the great confluence of the main stream - let FRS keep to his tributory where he is happy and secure.

What is it to be? The moss life cycle just for its own sake, or a resolution of conflicting values between art and science? Is it to be science for people, for social understanding and as a tool for meaningful value judgement? Or is it just to be the properties of magnesium, the laws of reflection and the principle of the inclined plane?

You must choose!

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A number of educators answered the letter asking for opinions about past, present and future trends in science teaching in Australia. I am most grateful for this help and co-operation. Most of those responding gave detailed replies and many included supplementary information. All those co-operating in the survey are listed below.

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(Those giving comprehensive replies to most questions and whose answers have been included in results shown in Tables 1 to 5)

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5. Betjeman, K.J. & Cornelius B. — Education Department, Perth, W.A. 6005
6. Birch, L.C. — University of Sydney, Sydney, N.S.W. 2006

7.	Butts, W.	Macquarie University, North Ryde, N.S.W. 2113
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13.	Dircks, R.	Chatswood High School, Chatswood 2067
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31.	Rowlands, R.G.	Victorian Universities and Schools Examinations Board, Melbourne, Vic. 3004
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5.	Butler, S.	University of Sydney, Sydney, N.S.W. 2006
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10.	Massey, D.	All Saints College, Bathurst, N.S.W. 2795
11.	Pendlebury J.	Sydney Teachers College, Sydney, N.S.W. 2042
12.	Sandercock E.	S.A. Science Teachers Association, Parkside, S.A. 5063
13.	Wessen J.P.	Granville South High School, Guildford, N.S.W. 2161

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